ORIGINAL ARTICLE
Hip Pelvis 30(1): 18-22, 2018
http://dx.doi.org/10.5371/hp.2018.30.1.18

Print ISSN 2287-3260
Online ISSN 2287-3279
Hip & Pelvis

# Total Hip Arthroplasty Using Ceramic-on-ceramic Bearing Surfaces: Long-term Assessment of Squeaking Sounds

**Min Wook Kim, MD, Sang Min Kim, MD, Young Yool Chung, MD**
*Department of Orthopaedic Surgery, Kwangju Christian Hospital, Gwangju, Korea*

**Purpose**: This study was performed to characterize the natural history of squeaking sounds that occur following total hip arthroplasty (THA) using ceramic-on-ceramic bearing surfaces and its potential correlation with clinical and/or radiological results.
**Materials and Methods**: This study included 47 patients who underwent THA between April 1999 and April 2005, and had at least 10 years of follow up from the time of the operation. Squeaking sounds were detected in 10 out of the 47 cases (21.3%). Squeaking-associated factors (i.e., cause, time of onset, inducing motions, and continuity of the sound) were assessed.
**Results**: Squeaking sounds: i) were detected an average of 46.2 months after operation, ii) occurred more frequently in patients with a high body mass index (BMI) compared to those with low BMI, and iii) most frequently detected when deep flexion of hip joint followed extension. In all 10 cases, the squeaking sound remained through the follow up period; 6 cases experienced no change in frequency and pitch, 4 cases experienced a decrease in frequency and pitch over time. The cause(s) of changes to squeaking sounds could not be determined.
**Conclusion**: The frequency and pitch of the squeaking sounds changed over time in a subset of patients. The squeaking sound did not appear to correlate with clinical results or survival of the prosthesis.

**Key Words**: Total hip arthroplasty, Ceramic bearing surfaces, Squeaking sound

## INTRODUCTION

Implants with ceramic bearing surfaces are widely used in total hip arthroplasty (THA) and the preferred choice for younger and more active patients because they are: i) more resistant to wear, ii) have less periprosthetic osteolysis-caused loosening, and iii) improved implant survival rates[1-3]. Although ceramic liner and femoral head breakage was reported in the early years[4-6], the risk of breakage has dramatically decreased with the distribution of the fourth-generation ceramic-on-ceramic (CoC) bearings, following the third-generation CoC bearings manufactured by hot isostatic pressing and laser marking[7,8]. However, squeaking sounds have been reported following THA performed

Submitted: December 1, 2017 1st revision: January 5, 2018
2nd revision: January 12, 2018 Final acceptance: January 13, 2018
Address reprint request to
**Young Yool Chung, MD** (ORCID 0000-0002-4959-1230)
Department of Orthopaedic Surgery, Kwangju Christian Hospital, 37 Yangrim-ro, Nam-gu, Gwangju 61661, Korea
TEL: +82-62-650-5064 FAX: +82-62-650-5066
E-mail: paedic@chol.com

using the fourth-generation ceramic bearings[9-11]. The incidence of squeaking sounds in CoC hip replacements varies in the literature (range, 3.1-30%), and a higher rate of squeaking has been reported in taller, heavier, younger, and more active patients[12-14]. The cause(s) of squeaking noises has not yet been completely elucidated, and natural history studies assessing changes in the pitch and frequency of squeaking sounds are rare. A previous report documented no changes in pitch and frequency, but the study was limited by the relatively short follow-up period[15]. Here, we characterized the natural course of squeaking and evaluated the potential correlation between squeaking and clinical and radiological outcomes. Our study included patients who experienced squeaking sounds after THA using CoC bearing surfaces during a long-term follow-up ($\geq$10 years).

## MATERIALS AND METHODS

This study included 47 of 61 cases that underwent THA using CoC bearings in Kwangju Christian Hospital from April 1999 to April 2005. The remaining 14 cases were excluded due to a lack of sufficient follow up. The mean age at the time of surgery was 52.9 years (range, 24-70 years), and 38 males and 9 females were included. The mean postoperative follow-up period was 14 years (range, 10.5-17 years). All operations were performed by a single surgeon via the posterolateral approach. The acetabular cups used were Bicontact® (Aesculap, Tuttlingen, Germany) in 24 cases, Osteonics® (Stryker, Kalamazoo, MI, USA) in 17 cases and ABGII® (Howmedica, Newbury, UK) in 6 cases. The femoral stems used were Bicontact® in 24 cases and ABGII® in 21 cases. All femoral heads and acetabular liners used alumina ceramic components.

A squeaking sound was defined as a high-pitched audible sound that is directly heard by the observer and occurs during movement of the hip joint at outpatient visit. Clicking or popping sounds were excluded. To identify the causes of squeaking sound, patients' age, sex, weight and height were examined and the anteversion and coverage angles of the acetabular cup were measured on anteroposterior and lateral views of the hip. Clinical results were evaluated with the Harris Hip Score (HHS). The degree of effect of squeaking on activities of daily living was assessed based on the rating form devised by the authors of this study (Table 1).

To explore the postures in which squeaking sounds were heard, the survey was carried out by subdividing postures into: i) ground walking, ii) stair walking, iii) sitting, and iv) standing. We further investigated whether there were changes in squeaking frequency and/or pitch from the period when the patient first recognized the sound to final follow-up. Since the frequency and pitch of the sound cannot be expressed numerically, assessment was done based on feedback from patients and family members who responded to a survey. To identify the factors affecting the change in frequency and pitch of the sound, we compared age, sex, weight, height, follow-up duration and radiological outcomes between patients with changes and those without.

The Mann-Whitney *U*-tests and chi-square tests were used. Statistical analyses were performed using the PASW Statistics version 18.0 (IBM Co., Armonk, NY, USA). Differences were considered statistically significant at $P<0.05$. This study was performed after gaining an approval from the institutional review board of Kwangju Christian Hospital (KCH-2015-01-003).

## RESULTS

Squeaking occurred in 10 (21.3%) of 47 cases. New audible noises of the hip did not occur during the follow-up period in any patient. No significant differences were observed between the occurrence of sound by age at the time of surgery or sex. However, patients with squeaking had a higher mean body mass index (BMI) of 25.8 kg/m$^2$ than those without ($P$=0.001). Squeaking occurred at a higher rate in hips implanted with Osteonics®, but this difference was not statistically significant. The average

**Table 1.** Grade of Restriction of Daily Living Activities by Squeaking

| Grade | Restriction of daily living activities |
|---|---|
| I (Mild) | Only sound exists without any discomfort |
| II (Moderate) | I. Intermittent sound |
| | II. Patients deliberately restrict the motion not to make the sound in public |
| II (Severe) | I. Continuous sound |
| | II. Revision is considered seriously due to the sound |

anteversion and coverage angles of the acetabular cup were 43.2˚ and 17.5˚, respectively, in patients with squeaking; 43.2˚ and 20.6˚, respectively, in patients with no squeaking; there were no significant differences among these comparisons (Table 2).

The mean time to onset of squeaking after surgery was 46.2 months (range, 6-74 months). Squeaking sounds most commonly occurred while rising up from a squat position to a standing position (7 cases) and walking up and down stairs (2 cases) and ground walking (1 case). No patients experienced complete remission of squeaking, but the frequency and pitch of the sound decreased in 4 (40.0%) cases during follow-up. However, the cause of the decrease in frequency and pitch of the sound was not determined (Table 3).

The mean HHS was 88 in patients with squeaking at the last follow-up, showing no difference compared to those without the sound. Squeaking had no influence on clinical outcomes, but 8 patients had moderate restriction in daily life (i.e., becoming conscious of other people because of the sound). Revision surgery was conducted in 1 case with squeaking at the last follow-up due to destruction of the prosthetic head. Surgical treatment was undertaken in 2 cases without the sound due to periprosthetic fracture. No patients underwent revision due to prosthetic loosening.

## DISCUSSION

The incidence of ceramic breakage, one potential complication following THA using CoC bearing surfaces has declined dramatically with the use of fourth generation CoC bearings. Squeaking sounds, which have been reported as a new complication, have not been well characterized with long-term studies and their cause(s) remain highly debated. Walter et al.[16] reported a very low incidence of squeaking sounds (0.66%). Other, more recent studies, have documented that the prevalence of squeaking sounds after CoC THA range between 1.1% and 6.0% in the third and fourth generation ceramic bearings[9-11]. Salo et al.[9] and Gillespie et al.[14] observed incidence rates of 17% and 30%, respectively. In our study, squeaking sounds occurred in 21.3% of patients as determined by conducting a thorough inquiry into the patient's status concerning squeaking sound.

**Table 2.** Demographic Data of Squeaking and No-squeaking Group

| Variable | Squeaking (n=10) | No squeaking (n=37) | *P*-value |
|---|---|---|---|
| Age (yr) | 54.5 | 52.5 | 0.394 |
| Gender (male:female) | 9:1 | 29:8 | 0.426 |
| Duration of follow up (mo) | 173.2 | 168.0 | 0.140 |
| Cup positioning (˚) | | | |
| Inclination | 43.2 | 43.2 | 0.623 |
| Anteversion | 17.5 | 20.6 | 0.220 |
| Kind of prosthesis | | | 0.129 |
| Body mass index (kg/m$^2$) | 25.8 | 23.0 | 0.001 |
| Harris Hip Score | 88 | 86.2 | 0.645 |
| Complication, n (%) | 1 (10.0) | 5 (13.5) | 0.788 |

**Table 3.** Changes of Pitch and Frequency of Squeaking Sound

| Variable | Changed (n=4) | Persistent (n=6) | *P*-value |
|---|---|---|---|
| Age (yr) | 52.0 | 55.8 | 0.520 |
| Duration of follow up (mo) | 172.1 | 173.6 | 0.990 |
| Cup positioning (˚) | | | |
| Inclination | 41.8 | 46.0 | 0.273 |
| Anteversion | 18.3 | 16.7 | 0.657 |
| Kind of prosthesis | | | 0.764 |
| Body mass index (kg/m$^2$) | 25.9 | 25.5 | 0.787 |
| Harris Hip Score | 89.3 | 86.8 | 0.717 |

The sound in CoC bearing surfaces is seems to occur at a frequent rate, but the reported low prevalence seems attributable to the fact that patients do not complaint squeaking sound because it is not associated with any pain or clinical differences and physicians do not inquire about whether the patient is experiencing this noise.

Several authors have pointed out that height (i.e., taller patients) and higher BMI may be factors which lead to the initiation of squeaking sounds[12,13,16]. In our study, higher BMI significantly correlated with the occurrence of squeaking. For this reason, the risk of squeaking sound after THA using CoC bearings should be fully explained to patients before surgery especially in patients with higher BMI.

In the current study, squeaking sounds were most frequently detected when the hip joint moves from flexion to extension, in particular when rising up from a squatting posture to a standing position (7 cases), or while walking (3 cases).

Restrepo et al.[15] reported that squeaking sounds occurred while walking on ground in 38%, stair walking in 24%, and during deep hip flexion in 21%. Unlike Americans or Europeans, Koreans, because of lifestyles, are more likely to take a squatting position at lower levels than chair-sitting postures; differences between our results and the results from Restrepo et al.'s study[15] is thought to be attributed to this reason. Based on our analysis, high BMI and postures that impose heavier weight on the hip joint are found to increase the incidence of squeaking sounds. Patients with squeaking after THA may experience limitations in activities of daily living and undergo revision surgery[17]. In this study, 8 patients were experiencing stress due to the sound. In particular, patients who emit a high-pitch noise when they move had increased movement restrictions (e.g., concerns for other people around them). For this reason, we became more interested in squeaking sounds, and aimed to investigate, through a long-term follow up study: i) changes in the pitch and/or frequency of squeaking sounds and ii) the potential correlation between squeaking sounds and clinical and/or radiological outcomes. Although no patients experienced complete remission of squeaking (consistent with other studies), the frequency and pitch of the sound were decreased in 4 (40.0%) cases during the follow-up. Previous studies have only examined the presence or absence of the sound; no studies have characterized changes in frequency and/or pitch of squeaking sounds. However, this study was meaningful in that it revealed that changes in the pitch and/or frequency of squeaking sounds after CoC THA over time do occur. Since this study was limited by the relatively small sample size, we were unable to identify the causes for changes in pitch and frequency of the sound. No factors between the 4 cases with change in squeaking sound and the 6 cases without any change were shown to be significantly different. Further studies with a much larger sample size may help elucidate the cause(s) for changes to squeaking sounds.

With respect to the impact of squeaking sound on clinical outcomes, Salo et al.[9] suggested that patients with squeaking sounds had a lower Oxford Hip Score. Abdel et al.[18] recommended revision in patients associated with pain. On the contrary, Restrepo et al.[15] and Sexton et al.[12] documented that squeaking sounds had no influence on clinical results. Stanat and Capozzi[11] reported that no differences in clinical results were found between THA patients (with fourth-generation CoC bearings) with squeaking sound and those without. After a long-term follow-up of more than 10 years, no patients in our study reported pain, despite the presence of squeaking sound. Furthermore, patients with squeaking showed no difference in clinical outcomes compared to those without the sound. A patient with squeaking sound and an Osteonics® cup implant underwent revision surgery due to destruction of the prosthetic head 11 years after THA. Since there were no specific findings correlating the sound with prosthetic loosening or osteolysis, squeaking sound appears to have no direct impact on implant survival. Even though, our study findings have been achieved based on long-term follow-up, we are limited to draw conclusion on the effect of squeaking sound on implant survival due to the small sample size. Multicenter long-term follow-up studies are thought to be warranted to further characterize squeaking sounds.

## CONCLUSION

Squeaking sound after THA using CoC bearing surfaces has been recognized as a adverse event that can negatively affect the daily lives of patients The risk of squeaking sound following CoC bearing THA should be clearly explained to patients before surgery especially in those with higher risks. However, squeaking sound was found to have no negative impact on clinical and radiological outcomes.

## CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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## REFERENCES


1. Hamadouche M, Boutin P, Daussange J, Bolander ME, Sedel L. *Alumina-on-alumina total hip arthroplasty: a minimum 18.5-year follow-up study. J Bone Joint Surg Am. 2002;84-A:69-77.*
2. Bizot P, Nizard R, Hamadouche M, Hannouche D, Sedel L. *Prevention of wear and osteolysis: alumina-on-alumina bearing. Clin Orthop Relat Res. 2001;(393):85-93.*
3. Yoo JJ, Kim YM, Yoon KS, Koo KH, Song WS, Kim HJ. *Alumina-on-alumina total hip arthroplasty. A five-year minimum follow-up study. J Bone Joint Surg Am. 2005;87:530-5.*
4. Ha YC, Kim SY, Kim HJ, Yoo JJ, Koo KH. *Ceramic liner fracture after cementless alumina-on-alumina total hip arthroplasty. Clin Orthop Relat Res. 2007;458:106-10.*
5. Hasegawa M, Sudo A, Hirata H, Uchida A. *Ceramic acetabular liner fracture in total hip arthroplasty with a ceramic sandwich cup. J Arthroplasty. 2003;18:658-61.*
6. Park YS, Hwang SK, Choy WS, Kim YS, Moon YW, Lim SJ. *Ceramic failure after total hip arthroplasty with an alumina-on-alumina bearing. J Bone Joint Surg Am. 2006;88:780-7.*
7. Buttaro MA, Zanotti G, Comba FM, Piccaluga F. *Primary total hip arthroplasty with fourth-generation ceramic-on-ceramic: analysis of complications in 939 consecutive cases followed for 2-10 years. J Arthroplasty. 2017;32:480-6.*
8. Aoude AA, Antoniou J, Epure LM, Huk OL, Zukor DJ, Tanzer M. *Midterm outcomes of the recently FDA approved ceramic on ceramic bearing in total hip arthroplasty patients under 65 years of age. J Arthroplasty. 2015;30:1388-92.*
9. Salo PP, Honkanen PB, Ivanova I, Reito A, Pajamäki J, Eskelinen A. *High prevalence of noise following Delta ceramic-on-ceramic total hip arthroplasty. Bone Joint J. 2017;99-B: 44-50.*
10. Wang W, Guo W, Yue D, et al. *Fourth-generation ceramic-on-ceramic total hip arthroplasty in patients of 55 years or younger: short-term results and complications analysis. Chin Med J (Engl). 2014;127:2310-5.*
11. Stanat SJ, Capozzi JD. *Squeaking in third- and fourth-generation ceramic-on-ceramic total hip arthroplasty: meta-analysis and systematic review. J Arthroplasty. 2012;27:445-53.*
12. Sexton SA, Yeung E, Jackson MP, et al. *The role of patient factors and implant position in squeaking of ceramic-on-ceramic total hip replacements. J Bone Joint Surg Br. 2011; 93:439-42.*
13. Chevillotte C, Pibarot V, Carret JP, Bejui-Hugues J, Guyen O. *Hip squeaking: a 10-year follow-up study. J Arthroplasty. 2012;27:1008-13.*
14. Gillespie JA, Kennedy JW, Patil SR, Meek DR. *Noise production in ceramic-on-ceramic total hip arthroplasty is associated with lower patient satisfaction and hip scores. J Orthop. 2016;13:282-4.*
15. Restrepo C, Matar WY, Parvizi J, Rothman RH, Hozack WJ. *Natural history of squeaking after total hip arthroplasty. Clin Orthop Relat Res. 2010;468:2340-5.*
16. Walter WL, O'toole GC, Walter WK, Ellis A, Zicat BA. *Squeaking in ceramic-on-ceramic hips: the importance of acetabular component orientation. J Arthroplasty. 2007;22: 496-503.*
17. Owen D, Russell N, Chia A, Thomas M. *The natural history of ceramic-on-ceramic prosthetic hip squeak and its impact on patients. Eur J Orthop Surg Traumatol. 2014;24:57-61.*
18. Abdel MP, Heyse TJ, Elpers ME, et al. *Ceramic liner fractures presenting as squeaking after primary total hip arthroplasty. J Bone Joint Surg Am. 2014;96:27-31.*